

Resource and Hazard Analysis of Selected Farmland Communities Along Bicol River

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Abstract

This study provides information on resource and hazard maps in selected farmland communities along Bicol River Basin. It specifically identifies and maps-out the agri-fishery resources, climate-related hazard areas, agricultural infrastructures, landmarks and other relevant resources and determines the climate adaptation practices and strategies of agriculture and livestock in the community. Resource and hazard mapping was used as a tool in the Participatory Rural Appraisal (PRA). Six communities from representative project beneficiaries from the Department of Agriculture Project Funded namely Baao (Sta. Eulalia and San Francisco), Canaman (Mangayawan and San Francisco) and Minalabac (Taban and Del Carmen-Del Rosario) were the participants. Results of PRA revealed that the majority of land resources in the barangays are being utilized in rice, high-value crop and corn farming while fishing, livestock, and poultry are considered other livelihood sources. Their geographic location and advantage is also its weakness in agriculture as a significant part of its farmland is prone to flooding during the wet season and drought during the dry season. Both sites in Canaman also experience saline intrusion. Most farmers practice adaptation strategies like using early maturing, submergence tolerant and saline-tolerant, and seeking another potential source of livelihood. The resource and hazard map not just depicts various aspects related to agriculture; it is also a useful tool to enhance resilience from natural hazards and disasters.

Keywords: *Resource and Hazard Map, Participatory Rural Appraisal (PRA), Rice Farming, Farming, Bicol River, Bicol River Basin*

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1. Introduction

Agriculture can reduce poverty, increase incomes, and improve food security for 80% of the world's poor, who live in rural areas and work mainly in farming (World Bank, 2022). In the Philippines, agriculture plays an important role in the economy. For instance, in 2021 alone, agriculture contributed 10.17% share in the gross domestic product (GDP) of the country (Philippine Statistics Authority (PSA), 2022). For Filipinos, agriculture is an important source of livelihood. In fact, the labor force survey report of PSA (2022) revealed that there are 9.73 million Filipinos in the agriculture industry.

Every region in the country develops different interventions to maximize agricultural potential. As such, the Department of Agriculture (2020) reported the Bicol region as one of the major contributors in the country's production in agriculture where the primary crops are rice, corn, coconut, abaca, pineapple, sweet potato, banana and other crops. In order to achieve food self-sufficiency and lessen the nation's reliance on imports, several concerned government agencies work together to promote innovative farming technology. However, there is still a need for research-based initiatives to boost agricultural outputs, particularly key issues like natural disasters, growing global population and workforce shortage in agriculture which are openly apparent (Laureta et al., 2022).

Natural disasters in the Philippines have a high impact on its agriculture sector. This is evident in nations where powerful typhoons pose a serious threat to lives and livelihoods. To minimize the negative impacts of natural calamities, the Republic Act (RA) 10121, otherwise referred to as the Philippine Disaster Risk Reduction and Management Act, was passed in 2010 reconstituting the National Disaster Risk Reduction and Management Council (NDCC) into the National Disaster Risk Reduction and Management Council (NDRRMC). With this, the Local Government Units (LGUs) are mandated to: design, program and coordinate disaster risk reduction and management activities; conduct risk assessments and contingency planning; consolidate local disaster risk information and climate change risks; maintain a local risk map; conduct training, orientation and knowledge management activities on disaster risk reduction and management; operate a multi-hazard early warning system; formulate and implement a comprehensive, integrated local disaster risk reduction and management plan (LDRRMP) and identify, assess and manage hazards, vulnerabilities and risks. Under the Climate Change Act of 2009 (RA No. 9279), the barangays are mandated to be directly involved in prioritizing the climate change issues and in identifying

and implementing best practices and other solutions. The same law provides that the municipal LGUs shall consider climate change adaptation, as one of their regular functions. For years, emerging challenges were faced by national agencies, including but not limited to climate change and other natural disasters. Plan of actions and mitigating strategies were adopted to minimize the negative impacts and improve management practices.

Given the mandates to government agencies and the availability of local resources, the local community expects visible mitigating strategies and sustainable practices. This emanates from the proper identification of resources and hazards in the community in order to formulate courses of actions as adaptation practices. In the Philippines, there are only few studies on resource and hazards mapping (i.e. Gacu et al., 2022; Cabrera & Lee, 2017; Morales & De Vries, 2021; Lagmay et al., 2017). Hence, this study aims to identify and map-out the agri-fishery resources, climate-related hazard areas, agricultural infrastructures, landmarks and other relevant resources and determine the climate adaptation practices and strategies of agriculture and livestock in the community along Bicol River. The results of the study serve as inputs to risk management plan.

2. Literature review

2.1. Farmland communities along Bicol River Basin

As generally known, the Philippines is known as an agricultural country. Observing provinces that have a vast layout of farmlands, agriculture provides a main source of livelihood and potential for further economic development for the country (Laureta et al., 2022). Moreover, the World Bank echoed the significance of providing attention and initiatives for better agriculture (Llorito, 2020), especially in the trying times brought by the COVID-19 pandemic. Thus, there are banner projects dedicated to the cause of agriculture development. In relation to that, Laureta et al. (2022) also indicated the participation of Bicol, among different regions, towards programs that aim for the betterment of the local agronomy, as reported by the Philippine Statistics Authority (2004).

Although the Bicol region has agricultural potential, it is also a frequent target of natural disasters such as typhoons. As indicated by Romero (2020), the Region is located at a vulnerable point which is within the typhoon corridor as well as the contributing geographical features (i.e., Mayon Volcano and the sea). The agro-watershed ecosystem known as The Bicol River Basin (BRB) encompasses about 317,103 hectares that include

natural resources and directly affects agri-fishery in the Region (The Bicol River Basin Project, 2021). Within the constant natural threats such as storms and large scale flooding, stressed in a 2021 study in terms of *“spatial and temporal aspects of agricultural productivity”*, households and work areas for farmers and fishermen are endangered. Hence, there is an important call for more initiatives such as research in agricultural outputs (Laureta et al., 2022). A 2015-updated brochure based on a study by the Food and Agriculture Organization of the United Nations (FAO, 2015) on the impact of natural hazards and disasters on agriculture in developing countries provided crucial findings such as the pronounced effect of around 22% economic impact of natural hazards and disasters directed towards the agricultural sector, the call for disaster risk reduction and resilience building, as well as the gap in terms of data on the effects of hazards and disaster on local agricultural sectors that must be addressed.

2.2. Agricultural hazards and resources

Literature and studies showed a constant threat to agriculture in the Bicol Region. As described by Laureta et al. (2022), areas of farmlands that are susceptible to natural hazards and disasters include the municipalities of Baao, Canaman, and Minalabac within the parameters of the Bicol River. Several studies resound the danger that brings about damage to the Philippine agriculture due to floods and typhoons (ADB, 2011). Moreover, the Asia Development Bank (ADB) reports a problem of deterioration in the agricultural field caused by unregulated extraction of natural resources and the effects of climate change. Highlighting climate change, Laureta et al. (2022) have also emphasized how the said concern is a posing challenge for policymakers, agriculture leaders, and farmers when it comes to cultivating the agricultural field. For this, ADB (2011) elaborated some of the consequences of climate change such as flood, typhoons, and droughts that all directly distress the state of agriculture.

Some recommendations for reducing and dealing with the aftermaths of hazards and disasters are investing in farming irrigation facilities (Laureta et al., 2022) and developing early warning systems that are accessible to the farmers and fisher folk (The Bicol Basin Project, 2021). As underscored in The Bicol River Basin Project (2021), strengthening risk management relies on *“better information, timely financing, contingency funds, and enabling policies and planning.”*

2.3. Participatory Rural Appraisal

In an attempt to respond to the need for further data on local agriculture as well as research on the effects of hazards and disasters on the field, this study mainly included the knowledge and information from the residents of the concerned areas themselves. Appropriately, the study depended on Participatory Rural Appraisal (PRA). According to Chambers (1994), approaches and methods within PRA are “*carried out by local rural or urban people themselves.*” It is a process of learning about the conditions of the problem from individuals that are directly affected (i.e., rural people). However, the learning process extends toward analysis, planning, and action, which are being carried out in the current study. As a matter of fact, there have been numerous studies over the years that have utilized PRA in agriculture such as farming systems research and problem identification and analysis by farmers (i.e. Ampt & Ison, 1988, 1989; Chambers, 1994).

This study also credits the fact of negative impacts brought by natural disasters as underlined in Israel and Briones (2013). As summated by the authors, the phenomena “*indirectly reduce the viability of both land and water ecosystems as suppliers of ecosystem services and endanger human health and safety with the proliferation of natural disaster-related diseases.*”

3. Methodology

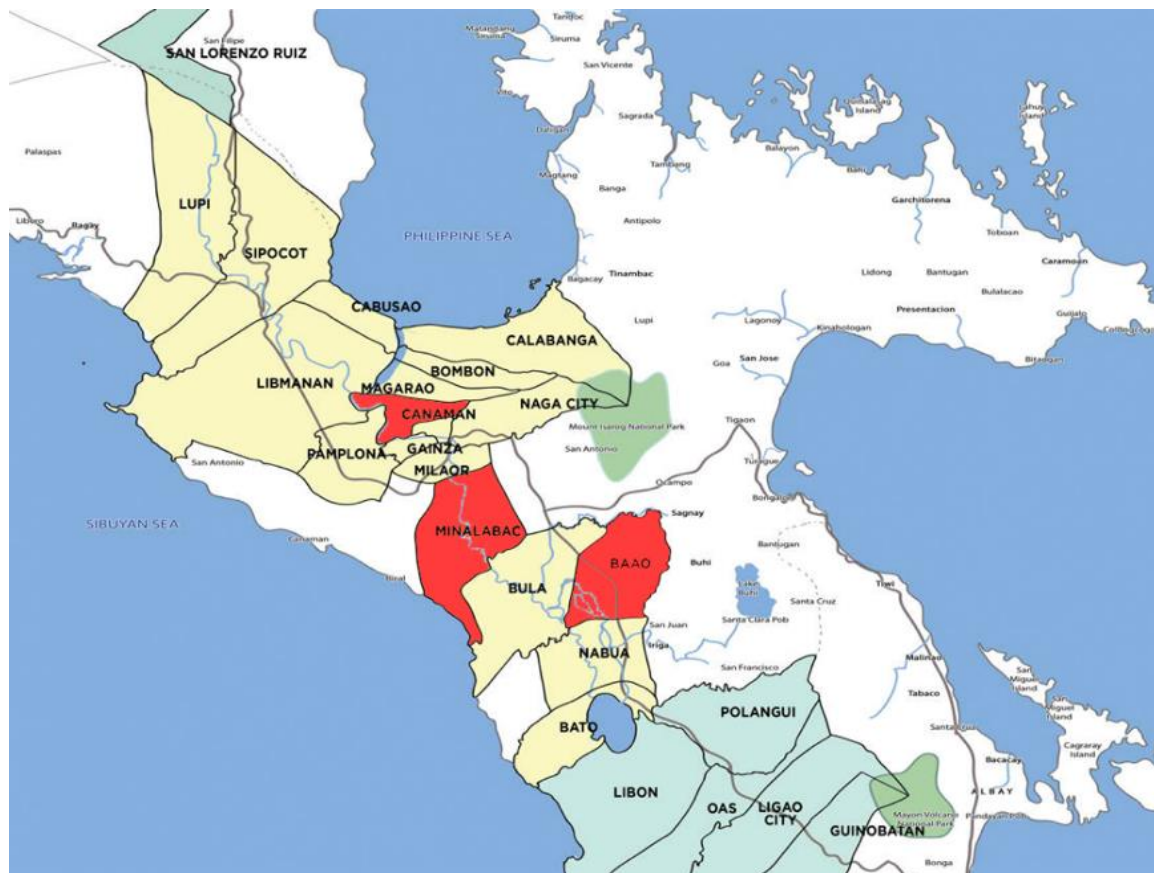
The study was conducted from July to September 2019. Six communities from representative project beneficiaries of the Department of Agriculture Project Funded were identified as participants of the PRA. It is the process of involving residents of a certain community in the analysis and interpretation of their own situation in a given rural area that often leads to planning, action, and participatory monitoring and evaluation (Chambers, 1994). The participants are the ones who lead in the information's collection, analysis, interpretation, and presentation. This process requires the participants to join in the conceptualization with the project team member as facilitators (Nigussie & Tesfaye, 2019). This process emphasizes the significance of empowering local people to assume an active role in analyzing their own living conditions, problems and potentials in order to seek for a change of their situation. It helps in resource and hazard identification which enables proper formulation of action plans for a specific rural area. The tool that was used in this study is

Resource and Hazard Map. Resource maps are used for depicting various aspects related to resource management. The primary concern is not to develop an accurate map but to get useful information about local perceptions of resources and hazards.

The barangay communities comprise the nominated areas of the LGU of three venerable municipalities of Camarines Sur namely Baao (Sta. Eulalia and San Fransisco), Canaman (Mangayawan and San Fransisco) and Minalabac (Taban and Del Carmen-Del Rosario) (Laureta et al., 2018) as shown in Figure 1.

Figure 1

Bicol river territorial map showing study sites from the Municipalities of Baao, Canaman and Minalabac in the Province of Camarines Sur, Bicol Region-V, Philippines



Source: Google Maps

One plenary session was conducted for each of the six communities. Specific number of key informants represented the different sectors of the community namely farmers, youths, Barangay Health Workers (BHW), housewives, and senior citizens, who were led by their

top barangay officials as shown in table 1. Before the session starts, the facilitator encourages all participants to actively share their knowledge and experiences in the activity.

Table 1

Breakdown of Participants to the PRA

Municipality	Community	Number of Participants
Bao	Sta Eulalia	42
	San Francisco	40
Canaman	Mangayawan	31
	San Francisco	34
Minalabac	Taban	32
	Del Carmen-Del Rosario	31
Total		210

PRA is more visual, encourages active local participation and empowers sharing approach (Chambers, 2014). The participants were asked to identify different agricultural resources, hazards, and threats and issues. They mapped out the agri-fishery resources, climate-related hazard areas, agricultural infrastructures, landmarks and other relevant resources through the spot map provided by the facilitators. Colored papers with labels or names of landmarks, resources, hazards were posted onto the map. The output of the resource and hazard mapping and identified problems, potential and solutions were recorded on another paper. A member from the group presented their output for validation. For triangulation, a key informant interview (KII) was conducted with barangay officials and municipal agriculturist.

4. Findings and Discussion

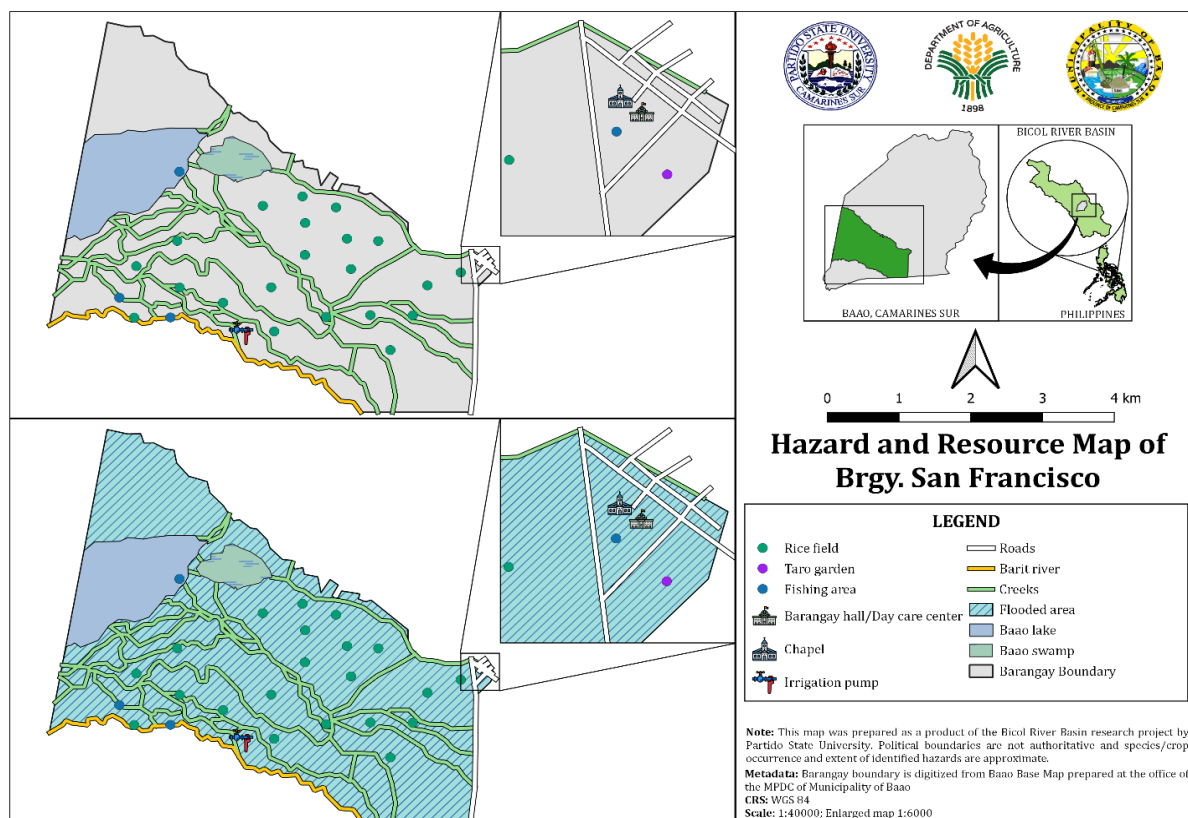
4.1. Resource and Hazard Map

Barangay San Francisco (Figure 2) is one of the six farmland barangays from representative project beneficiaries from DA Project Funded identified as participant of the Participatory Rural Appraisal (PRA). Formerly *Poblacion*, this barangay in the municipality of Bao, in the province of Camarines Sur, is classified as the mainland. It is situated at approximately 13.4505, 123.3350, on the island of Luzon. Elevation at these coordinates is estimated at 4.0 meters or 13.1 feet above mean sea level. As determined by the 2015

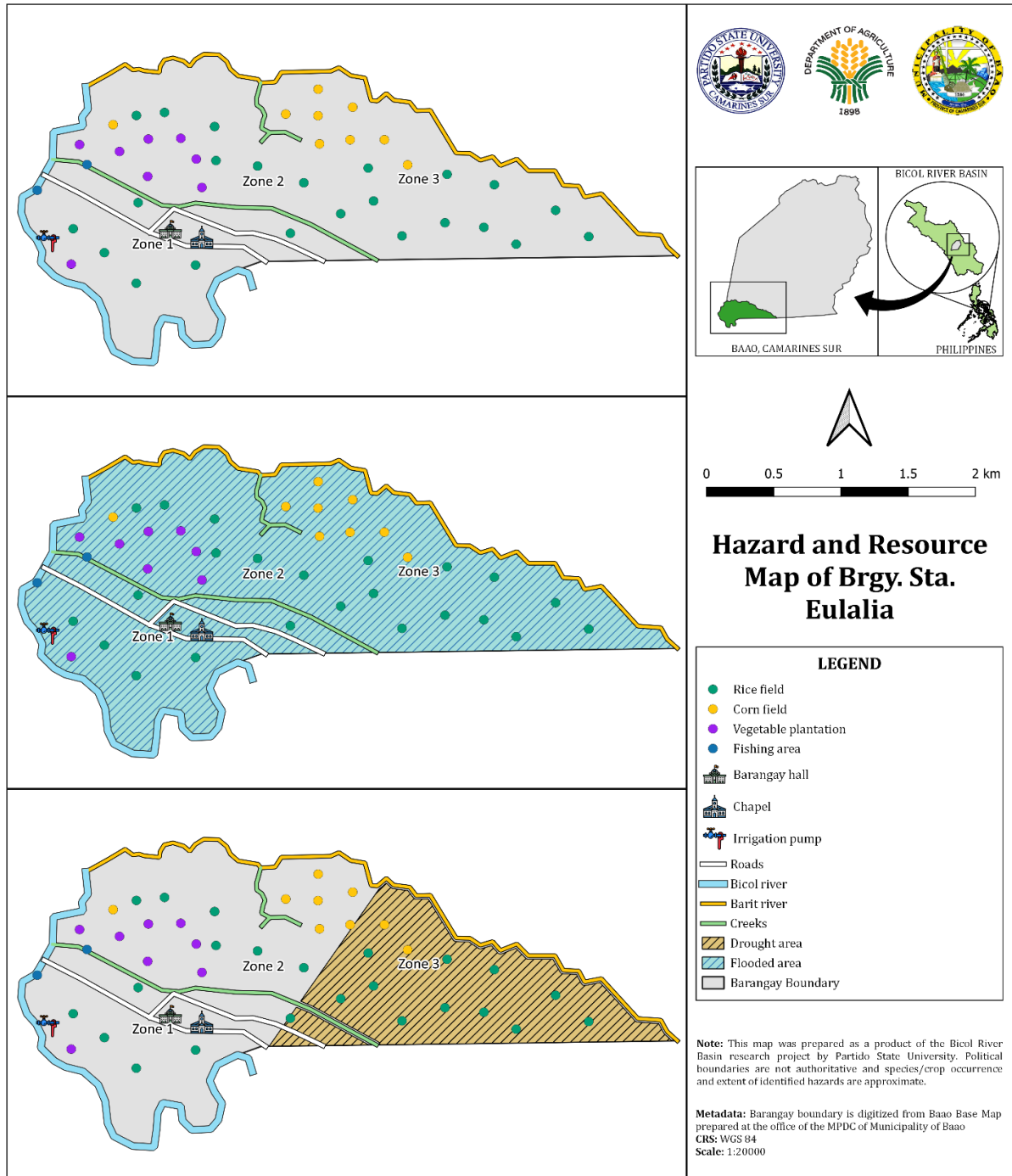
Census, its population was 2,447, representing 4.16% of the total population of Baao. The barangay is accessible by the Maharlika (main) Highway. It is one of the barangays surrounding Lake Baao. Barangay San Francisco has three puroks or zones. Visible landmarks in Zone 1 are Barangay Hall, Chapel, and Day-Care Center. The majority of its land is being utilized in rice farming, while fishing, livestock, and poultry are considered other livelihood sources. The barangay has an abundance of water supply from the lake, tributary rivers, and one irrigation facility. However, its geographic location and advantage are also its weakness in agriculture as a significant part of its farmland is prone to flooding during the wet season.

Figure 2

Resource and Hazard Map of Barangay San Fransisco in Baao, Camarines Sur



Barangay Sta Eulalia (Figure 3) is one of the two farmland barangay beneficiaries in the municipality of Baao from DA Project Funded. Its population, as determined by the 2015 Census, was 1,188. This represented 2.02% of the total population of Baao. Santa Eulalia is situated at approximately 13.4329, 123.3152, on the island of Luzon. Elevation at these coordinates is estimated at 4.0 meters or 13.1 feet above mean sea level.

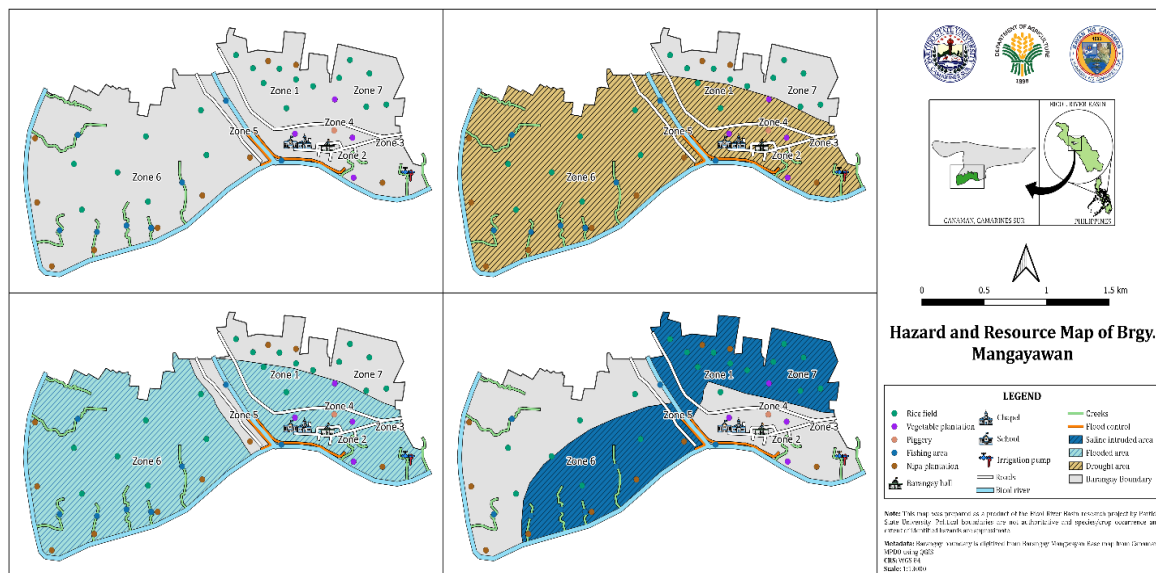
Figure 3*Resource and Hazard Map of Barangay Sta Eulalia in Baao, Camarines Sur*

The barangay is accessible by the Iriga-Baao Road and Pan-Philippine Highway. Santa Eulalia shares a common border with Palsong, Bula; Topas Sogod, Nabua, and San Francisco, Baao. Barangay Sta Eulalia has three puroks or zones. Visible landmarks in Zone 1 are Barangay Hall, Chapel, and Elementary School. Its topography is plains, rivers, and

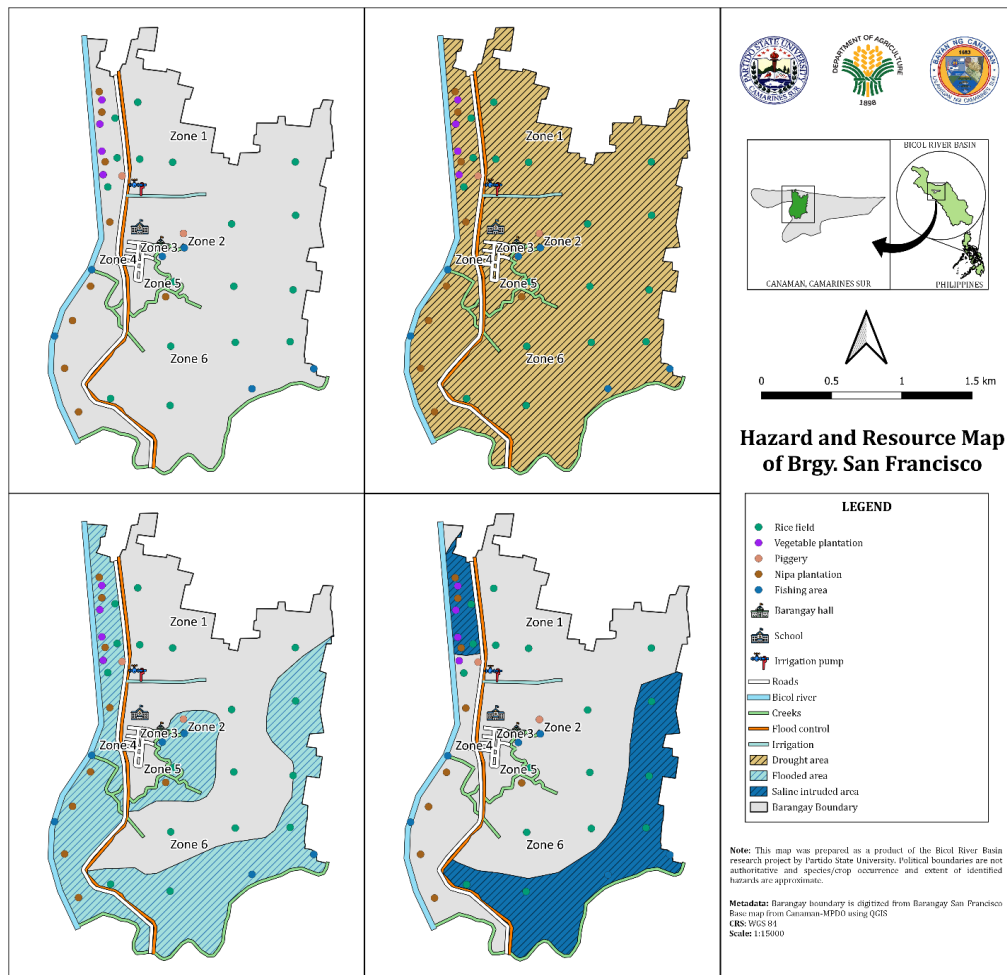
lakes. The majority of its land is being utilized in rice farming, while fishing is considered another livelihood source. The barangay has an abundance of water supply from the tributary rivers, Lake Baao, and no irrigation facility. Like other lowland barangays in Baao, Sta Eulalia is also prone to flooding during the wet season.

Figure 4

Resource and Hazard Map of Barangay Mangayawan in Canaman, Camarines Sur



Barangay Mangayawan (Figure 4) is a barangay in the municipality of Canaman, in the province of Camarines Sur. As determined by the 2015 Census, its population was 1,744, representing 5.10% of the total population of Canaman. Mangayawan shares a common border with Malbong Gainza, San Jose Canaman, and Loob Gainza. The barangay is accessible through provincial and municipal roads. It has seven puroks or zones. Visible landmarks are Barangay Hall, Chapel, and Day-Care Center. Farming, fishing, and small business, including piggery and handicraft, are the primary sources of employment and household income. Various cottage industries like handicraft, furniture, fan making (made of anahaw), ragiwdiw, and nipa shingles are also made from neighboring barangays in the municipality. The barangay is situated along the Bicol River and its branches. A large part of its farmland is prone to flooding during the wet season, while zones 5 and 6 are saline water intruded. The irrigation facility built by National Irrigation Authority (NIA) is ineffective as it produces salty water.

Figure 5*Resource and Hazard Map of Barangay San Francisco in Canaman, Camarines Sur*

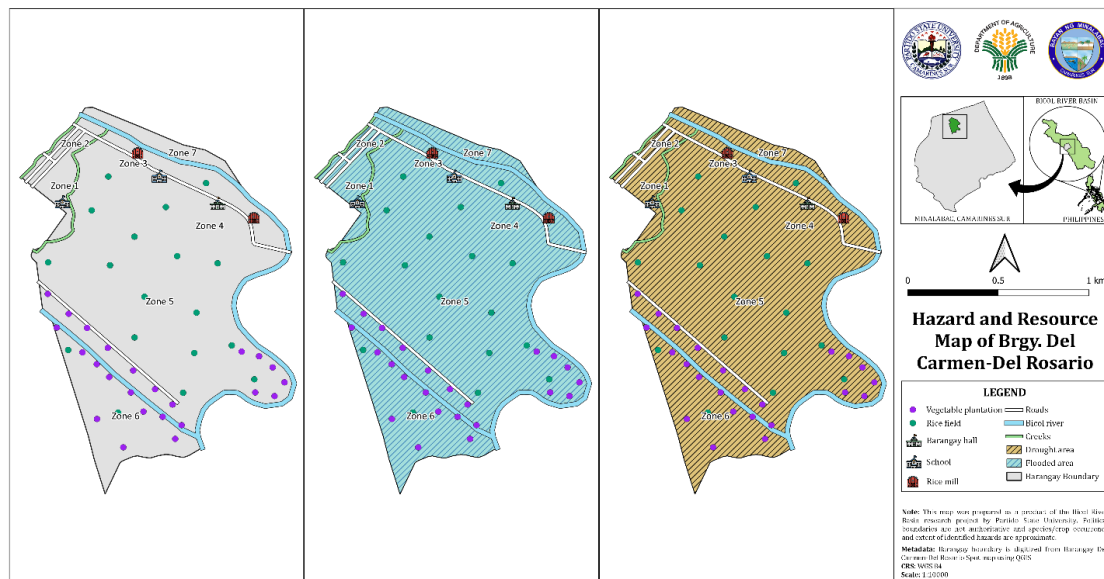
Barangay San Francisco (Figure 5) is bounded on the south by barangay Fundado, west by barangay Liaga, and southeast by barangay San Nicolas. It has an aggregate area of 378.3536 or 8.70% of the municipality's total land area. The entire six puroks of the barangay are serviced by tricycles that ply the route of Poblacion-Liñaga and boat. Given the road condition and the proximity of the barangay to the town proper (poblacion), public transportation for barangay San Francisco is not accessible, especially during night time.

Barangay San Francisco has six puroks or zones. Visible landmarks are Barangay Hall, Health Center, Chapel, Day Care Center and Elementary School. Farming, fishing, and small business, including piggery and handicraft, are the primary sources of employment and household income. Various cottage industries like handicraft, furniture, fan making (made of anahaw), ragiwdiw, and nipa shingles are also made from neighboring barangays in the municipality. The barangay is situated along the Bicol River and its branches. A large part of

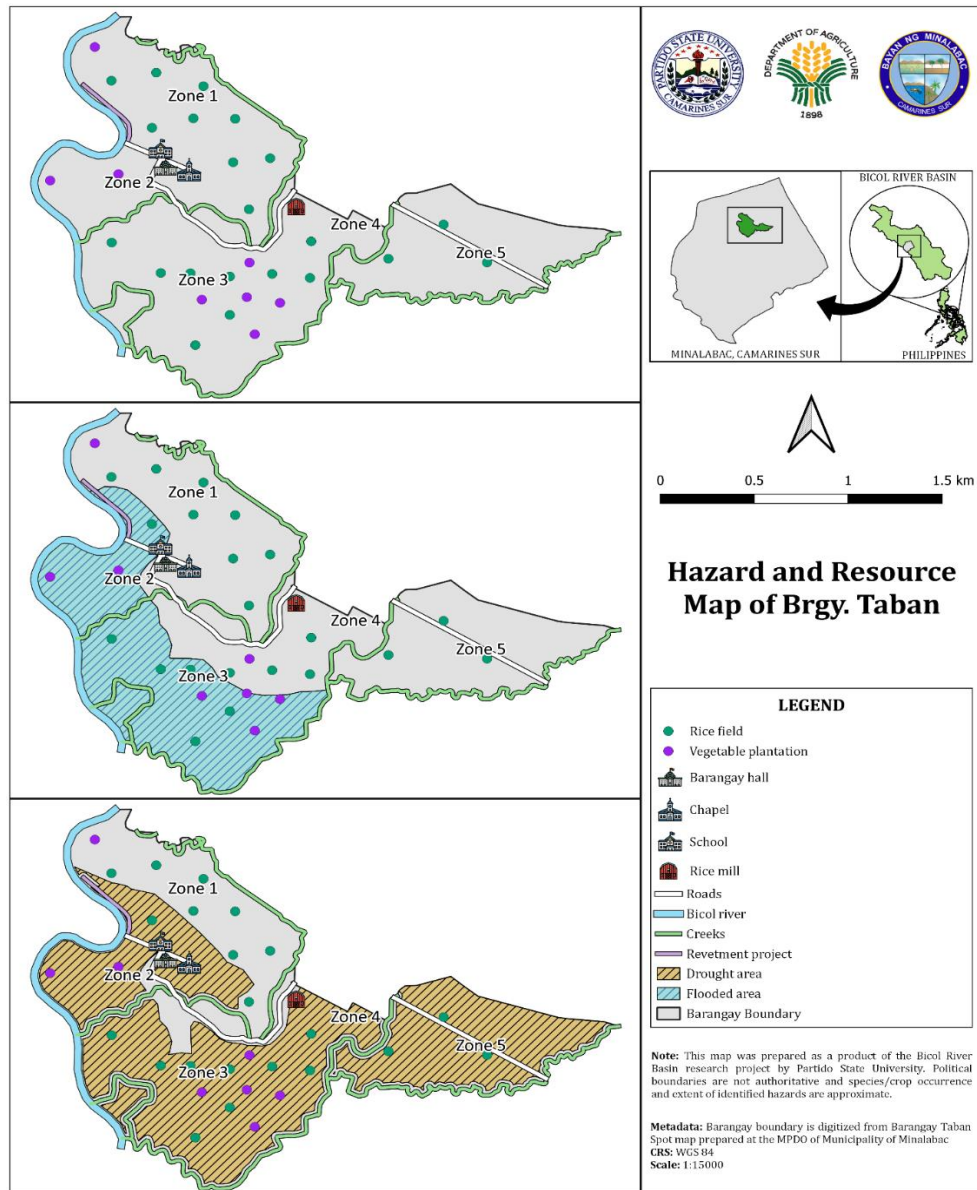
its farmland is prone to flooding during the wet season. Moreover, parts of farmland are saline water intruded, while some areas experience drought during the dry season. Two out of three irrigation facilities built by the National Irrigation Authority (NIA) are ineffective as they produce salty water.

Figure 6

Resource and Hazard Map of Barangay Del Carmen-Del Rosario in Minalabac, Camarines Sur



Barangay Del Carmen-Del Rosario (Figure 6) is also known as DCDR. Formerly *Poblacion*, this barangay in the municipality of Minalabac, in the province of Camarines Sur, is classified as the mainland. Its population, as determined by the 2015 Census, was 2,225. Del Carmen-Del Rosario is situated at approximately 13.5655, 123.1907, on the island of Luzon. Elevation at these coordinates is estimated at 2.5 meters or 8.2 feet above mean sea level. The barangay is accessible by the Pili-Minalabac-Milaor Road and has seven puroks or zones. Visible landmarks in Zone 1 and 2 are Barangay Hall, Chapel, and Day-Care Center, elementary and high school. The majority of its land is being utilized in rice farming while high-value crops and livestock are considered other livelihood sources. There is no public irrigation facility in the barangay. Water supply from the river, tributary streams, and privately owned. A large part of its farmland is prone to flooding during the wet season.

Figure 7*Resource and Hazard Map of Barangay Taban in Minalabac, Camarines Sur*

Barangay Taban (Figure 7) is a barangay in the municipality of Minalabac, in the province of Camarines Sur. As determined by the 2015 Census, its population was 1,150, representing 2.20% of the total population of Minalabac. Taban is situated at approximately 13.5544, 123.1996, on the island of Luzon. Elevation at these coordinates is estimated at 6.1 meters or 20.0 feet above mean sea level. The barangay is accessible through the Pili-Minalabac-Milaor and Barangay roads and has five puroks or zones. Visible landmarks in Zone 1 are Barangay Hall, Chapel, and Elementary School. The majority of its land is being utilized in rice farming, while high-value crops and livestock are considered other livelihood

sources. The barangay is situated along the Bicol River and its branches. A large part of its farmland is prone to flooding during the wet season, but some areas experience drought during the dry season with the absence of proper irrigation.

2.2. Climate Adaptation Practices and Strategies of Agriculture and Livestock

Table 2

Climate-Resilient Agricultural and Livestock Practices and Strategies in all (6) Six Barangay Communities

CLIMATE-RESILIENT AGRICULTURAL AND LIVESTOCK PRACTICES AND STRATEGIES	BAAO		CANAMAN		MINALABAC	
	Sta Eulalia	San Francisco	Mangyawan	San Francisco	Taban	Del Carmen -Del Rosario
PCIC Risk Transfer. Prior to planting, avail of risk-transfer mechanisms such as insurance from PCIC. Insure also the livestock and other farm assets.	√	√	√	√	√	√
Early maturing, submergence-tolerant and saline-tolerant	√	√	√	√	√	√
Repair drainage system. Prevent water stagnation	√	√	√	√	√	√
Plant windbreakers. In areas exposed to strong winds, plants windbreakers such as cacao and ipil-ipil.	x	x	x	x	x	x
Cover crops. Plant indigenous cover crops in sloping areas to improve soil fertility and reduce soil erosion/conserves soil moisture in upland areas.	√	x	√	√	√	x
Biomass as mulch. Utilize rice hull or coconut husk as a natural mulch to vegetables to conserve and retain moisture, lower soil temperature and reduce water-stress damage while achieving the potential yield of crop	x	x	x	x	x	x
Integrate short-duration crops (Legumes, vegetables, white corn) to improve household food security.	√	x	x	x	√	√
Process for corn silage. If properly processed, it can be stored for a year to cover the feeds needed by the ruminants.	x	x	x	x	x	x
Practice value-adding of vegetables and native fruits (e.g nipa fruit. With proper processing, these products can be developed into an enterprise of the household	x	x	x	x	x	x
Seek other potential source livelihoods/food and or plant crops that can serve as an alternative staple during lean months	√	√	√	√	√	√
For high-value crops, use rain shelters or grow crops in greenhouses. Change of cropping calendar is recommended	√	x	x	x	√	√
Climate information system. Stay tuned to the weather and climate updates from PAGASA and issuance from the Department of Agriculture.	√	√	√	√	√	√
Designate evacuation shelter for livestock and animals relief parks	x	x	x	x	x	x
Designate seeds warehouse and seed bank	√	x	x	x	√	√

"√" indicates the application of the climate-resilient agricultural and livestock strategy, while "x" indicates the opposite.

The Philippines is one of the most vulnerable countries to several climate hazards like but not limited to flooding, landslide, and drought, which generate associated adverse socio-economic impact (Department of Environment and Natural Resources, 2019). The Department of Agriculture suggested twelve (12) climate resilient agriculture practices to minimize the risk of agricultural assets through adaptive and coping strategies. The summarized data from the PRA and KII (Table 2), shows that all six (6) barangay communities practices PCIC Risk Transfer prior to planting, use early maturing, submergence-tolerant and saline-tolerant seeds, repair drainage system to prevent water stagnation, seek other potential source of livelihood, food and/or plant crops that can serve as an alternative staple during lean months and use climate information system to get weather and climate updates from PAGASA and issuance from the Department of Agriculture. The table also shows that only Sta Eulalia, Baao and Taban and Del Carmen-Del Rosario, Minalabac integrate short-duration crops to improve household food security and have designated seeds warehouse/seed bank.

5. Conclusion

Findings of the study led to a conclusion that the six community barangays along Bicol River Basin have almost the same agricultural resources and experience similar hazards or threats. Rice farming is still the most evident staple crop and resource among all communities while corn, vegetable and other high value crop farming and livestock raising are among the other agricultural resources. As such, building modern and operational irrigation facilities in farming communities must be prioritized. In areas like Mangayawan and San Francisco in the Municipality of Canaman where irrigation facilities are either non-operational or produce saltwater, careful infrastructure planning and considering opinions of stakeholders in building irrigation facilities is vital. Results also showed that irrigation facilities are still a problem even in farming communities along the Bicol River Basin. Designing a farming calendar considering flooding during the wet season and drought in the dry season will be highly useful. Furthermore, all barangays experience flooding during the wet season and drought in the dry season. Community barangays like San Francisco and Mangayawan also experience saline intrusion. For this, encouraging farmers to apply Climate-Resilient Agricultural and Livestock Practices and Strategies can help farmers to be resilient. Lastly, the communities practice several Climate-Resilient Agricultural and

Livestock Practices and Strategies. However, none of them has designated evacuation shelters for livestock and animal relief parks.

In the light of the findings and conclusion, the following are proposed:

a. Proposed Flood, Drought, and Salt-water Intrusion Risk Management Plan

As one of the most disaster-prone countries in the world, efforts must be doubled to mitigate and reduce the impact of natural disasters (Department of Interior and Local Government, 2018). The Proposed Risk Management Plan in the three (3) identified hazards during the PRA namely flood, drought and salt water intrusions below serves as guide for emergency preparedness in agriculture industry. The main goal is to promote preparedness and responsiveness in all-hazard situations to minimize the negative impact and speed the recovery process.

Table 3

Proposed Flood Risk Management Plan

Hazard/ Threat	Identified Causes	Action Plan	Risk Reduction Measures for Future
Flood	Moderate-heavy rain Typhoon	Conduct assessment <ul style="list-style-type: none"> •Flood Risk Assessment •Climate change vulnerability assessment Preparedness <ul style="list-style-type: none"> •Risk education drills •Monitoring of early warning systems •Proper information dissemination and weather related forecast •Availability of communication equipment for more remote areas and establish multimedia information campaigns •Promote risk-transfer mechanisms such as insurance from PCIC for livestock and other farm assets. Response <ul style="list-style-type: none"> •Immediate response •Evacuate livestock and animals in relief parks •Designate seeds warehouse and seed bank Recovery Plan <ul style="list-style-type: none"> •Financial support to local government farmers •Implement and improve systematic damage assessments 	<ul style="list-style-type: none"> • Agriculture and water infrastructure investments • Repair drainage system. Prevent water stagnation •Flood warning system •Farm level improvements

The first major hazard identified during the PRA is flood caused by moderate to heavy rainfall and typhoons. According to PAGASA uneven distribution of rainfall, fairly well-defined wet season due to monsoons and other precipitation-producing weather phenomena like tropical cyclones are capable of bringing intense and excessive precipitation that may result in potentially disastrous phenomena. The proposed flood risk management plan (Table 3) shows action plans to minimize the risk during floods. The action plan includes conduct assessment where flood risk assessment and climate change vulnerability assessment must be implemented on a regular basis. To prepare for floods it is important to conduct risk education drills, monitoring of early warning systems, dissemination and weather related forecasts, establish multimedia information campaigns, and promote risk-transfer mechanisms such as insurance from Philippine Crop Insurance Corporation (PCIC) for livestock and other farm assets. In response to floods, immediate response, evacuation of livestock and animals in relief parks, and assigning designated seed warehouses and seed banks are vital to ensure safety and minimize economic losses. To aid farmers in recovery, financial support to local and national government must be in place. Implementation of systematic damage assessments is imperative to determine the damage and provide lifesaving food and water, and to help people rebuild their homes, crops and businesses. All stakeholders must be aware of their roles during an emergency and communicate efficiently in order for crisis management and response to be effective, with the public sector assuming the lead when the private sector is unable to handle the situation (OECD et al., 2021).

To minimize floor risk in the future improvement in infrastructure such as: building new small rainwater harvesting structures, water impounding structures and farm reservoirs; repair drainage system to prevent water stagnation; availability of flood warning system; and farm level improvements.

The second major hazard identified during the PRA is drought caused by dry season and absence of irrigation facilities. El Nino is a seasonal warming of the Pacific Ocean that upsets normal weather patterns and is causing droughts in Northern Philippines resulting in severe impacts on crop productivity, water availability, and food security (Porio et al., 2019).

The proposed drought risk management plan (Table 4) shows action plans to minimize the risk when drought occurs. The action plan includes conduct assessment where drought risk assessment and climate change vulnerability assessment must be implemented

on a regular basis. To prepare for drought it is important to monitor early warning systems, dissemination and weather related forecasts and establish multimedia information campaigns.

Table 4

Proposed Drought Risk Management Plan

Hazard/ Threat	Identified Causes	Action Plan	Risk Reduction Measures for Future
Drought	Dry season No irrigation	Conduct assessment <ul style="list-style-type: none"> •Drought Risk Assessment and Mapping •Climate change vulnerability assessment Preparedness <ul style="list-style-type: none"> •Monitoring of early warning systems • Proper information dissemination and weather related forecast •Availability of communication equipment for more remote areas and establish multimedia information campaigns Recovery Plan <ul style="list-style-type: none"> •Implement and improve systematic damage assessments •Financial support to local government farmers 	<ul style="list-style-type: none"> •Rehabilitation of upland small-scale irrigation systems for upland productivity and natural resources sustainability • Distribution of pump and engine sets to lowland areas with shallow groundwater and surface water • Community-based watershed management for sustainable water resources and livelihood development in critical watersheds of selected irrigation systems • Promotion of water-saving technologies in irrigated rice production systems • Strong water conservation campaigns

To aid farmers in recovery financial support to local and national governments must be in place and implementation of systematic damage assessments. To minimize drought risk in the future improvement in infrastructure such as: rehabilitation of upland small-scale irrigation systems for upland productivity and natural resources sustainability; distribution of pump and engine sets to lowland areas with shallow groundwater and surface water; community-based watershed management for sustainable water resources and livelihood development in critical watersheds of selected irrigation systems; promotion of water-saving technologies in irrigated rice production systems and; strong water conservation campaigns.

Table 5*Proposed Salt Water Intrusion Risk Management Plan*

Hazard/ Threat	Identified Causes	Action Plan	Risk Reduction Measures for Future
Salt Water Intrusion	Flood	Conduct assessment •Water supply assessment	• Agriculture and water infrastructure investments
	Irrigation facilities producing salt water	•Climate change vulnerability assessment •Proper maintenance of irrigation facilities Preparedness •Promote the use of submergence-tolerant and saline-tolerant seeds •Proper information dissemination and weather related forecast •Availability of communication equipment for more remote areas and establish multimedia information campaigns •Promote risk-transfer mechanisms such as insurance from PCIC for livestock and other farm assets Recovery Plan •Financial support to local government farmers •Implement and improve systematic damage assessments	•Monitoring of irrigation facilities •Consultation and needs assessment with farmers

Another hazard identified during the PRA is salt-water intrusion caused by flooding and faulty irrigation facilities producing saline water. The proposed flood risk management plan (Table 5) shows action plans to minimize the risk during salt-water intrusion in farmlands. The action plan includes conduct assessment where flood risk assessment, climate change vulnerability assessment must be implemented on a regular basis and proper maintenance of irrigation facilities. To prepare for flood it is important to promote the use of submergence-tolerant and saline-tolerant seeds, dissemination and weather related forecast, establish multimedia information campaigns, and promote risk-transfer mechanisms such as insurance from Philippine Crop Insurance Corporation (PCIC) for livestock and other farm

assets. For immediate recovery implementation of systematic damage assessments is imperative and financial support from local and national government must be given to farmers. According to the updated Philippine Development Plan 2017-2022, the government will step up its efforts to increase the efficiency of agricultural operations and lower production costs and post-harvest losses by facilitating the use of farm and fisheries machinery, equipment, and facilities that are appropriate for local needs and conditions. To minimize the risks and negative impacts of saline intrusion, investment in agricultural and water infrastructure is important. Monitoring of irrigation facilities and other public facilities is vital to ensure viability and efficiency. Conduct consultation and needs assessment with farmers to reveal the issues to be addressed.

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